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THE EFFECT OF LUMBODORSAL SPLANCHNICECTOMY ON THE BLOOD VOLUME AND "THIOCYANATE SPACE" OF PATIENTS WITH ESSENTIAL HYPERTENSION

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This investigation was undertaken as part of a comprehensive study of the effects of sympathectomy on the hemodynamic functions of patients with essential hypertension. It was considered worthwhile to rule out the possibility that the reduction in blood pressure is accompanied by significant alterations of total blood volume, and, incidentally, to obtain information on the effects of the operation on the intravascular and extracellular fluid compartments of the body.

Following sympathectomy in normal cats the plasma volume increased,[11] whereas, in dogs with experimental renal hypertension sympathectomy produced either no change[4] or a decrease in red cell volume.[16] The present report presents the results of blood volume and "available fluid" ("thiocyanate space") studies in patients with essential hypertension before and after lumbodorsal splanchnicectomy.

Materials and Methods. The subjects were a heterogeneous group of 10 patients with essential hypertension. The measurements of plasma volume using the dye T-1824, and of "available fluid" volume using a 5% solution of sodium thiocyanate intravenously were determined before operation and at various intervals after operation.

The method of Gregersen and Stewart[6] for the simultaneous determination of blood volume and "thiocyanate space" was modified for use with the Coleman junior spectrophotometer. The blood samples were collected in 4 cc. hematocrit tubes containing a measured amount of liquid oxalate mixture in isotonic saline as described by Emerson and Ebert.[2]

The plasma specific gravity of each sample was determined with the Barbour and Hamilton falling drop apparatus and the dyed plasma samples were corrected for fluid shifts as recommended by Gregersen.[7] After such correction straight line dye concentration curves were obtained on a semi-log plot (logarithm of the plasma dye concentration plotted against time). Using this method uniform rates of dye disappearance (approximately 5% in the 1st hour) were obtained, thus confirming the observations of Noble and Gregersen.[14] For this reason and because of the greater convenience we determined the plasma volume from the 10 minute sample in the latter half of this investigation.

Since in some individuals thiocyanate reaches an equilibrium with the extracellular fluid slowly, and because there is no appreciable change in concentration from the 1st to the 4th hour following injection,[1] the plasma samples used to calculate the "available fluid" volume were drawn $1\frac{1}{2}$ to 2 hours following injection. In view of the lack of adequate information concerning the precise volume distribution of thiocyanate "correction" factors were not used. The "available fluid" volume as used in this study expresses the total volume in which thiocyanate is distributed, including the plasma volume, the amount that enters the red cell, and its distribution in the extracellular space.

TABLE 1.—BLOOD VOLUME AND AVAILABLE (THIOCYANATE) FLUID CHANGES FOLLOWING LUMBODORSAL SPLANCHNICECTOMY.

Patient	Sex	Age	Time	Height (cm.)	Weight (kilo)	Blood pressure (mm. Hg)	Plasma volume (cc.)	Hematocrit (%)	Total blood volume (cc.)	Change (%)	"Available fluid" (cc.)	Change (%)
J. F.	M	25	Preoperative	175	80	155/100	2860	50.5	5720	...	20,500	
			P 1st stage 10 days		77	170/135	3110	45.0	5650	− 1	20,600	0
			P 2nd stage 12 days		76	135/95	2930	47.5	5610	− 2	24,100	+23
			3 months postoperative		78	120/85	2780	43.0	4880	−14	21,600	+10
			6 months postoperative		83	145/100	2930	47.5	5610	− 1.5	21,250	+ 9
E. L.	F	21	Preoperative	162	39	225/150	1575	40.5	2650	...	11,900	
			P 1st stage 8 days		39	170/100	1880	36.0	2950	+11	13,800	+16
			P 2nd stage 10 days		38	200/110	1680	39.0	2750	+ 5	13,100	+13
			3 months postoperative		40	115/88	2000	40.1	3350	+25	12,700	+ 8
			6 months postoperative		38	145/125	...	38.0	...	...	12,000	0
E. D.	M	35	Preoperative	176	77	165/135	3240	45.5	5950	...	20,200	
			P 2nd stage 12 days		72	170/120	3000	37.5	4800	−16	21,800	+16
			3 months postoperative		68	115/88	2900	42.5	5050	−10	18,200	−10
			6 months postoperative		77	135/95	3350	43.1	5900	− 1	19,600	− 3
J. Mc.	M	42	Preoperative	170	74	165/110	2760	45.5	5070	...	18,000	
			P 2nd stage 8 days		70	130/90	3260	36.5	5140	+ 5	22,600	+28
			3 months postoperative		72	145/100	3100	38.0	5000	− 1	16,400	− 9
			6 months postoperative		72	130/100	2840	42.7	4950	− 2	18,000	0
R. D.	M	27	Preoperative	181	64	220/140	3420	40.8	5970	...	19,200	
			P 1st stage 5 days		63	220/155	3250	37.0	5170	−10	19,500	+ 2
			Immediate P 2nd stage		...	160/130	3370	38.0	5430	− 6	21,800	+18
			P 2nd stage 12 days		62	185/140	3570	37.0	5680	− 1	20,400	+ 6
			6 months postoperative		65	195/155	3520	43.5	6230	+ 4	20,400	+ 6
W. R.	M	33	Preoperative	177	77	190/135	2660	48.0	5125	...	18,200	
			P 2nd stage 10 days		72	160/140	2220	51.0	4525	− 9	19,200	+13
J. S.	F	44	Preoperative	151	57	208/105	2300	40.0	3840	...	14,300	
			P 1st stage 5 days		57	140/86	2520	32.5	3740	− 3	13,800	− 3
			P 1st stage 10 days		57	160/95	2310	37.0	3675	− 5		
			P 2nd stage 15 days		57	165/110	2200	39.0	3620	− 6	14,700	+ 3
J. V	M	35	Preoperative	178	86	160/120	2840	48.8	5540	...	20,115	
			P 2nd stage 5 days		84	158/110	2760	44.5	4975	− 9	24,300	+24
			2 months postoperative		85	135/112	...	47.5				
J. W.	M	42	Preoperative	170	80	165/110	3210	44.7	5800	...	19,700	
			P 1st stage 10 days		77	210/110	3150	43.5	5570	− 4	22,600	+15
			P 2nd stage 20 days		73	140/96	3000	40.2	5000	−14	21,730	+22
C. C.	M	45	Preoperative	175	65	210/130	2550	53.0	5420			
			P 2nd stage 10 days		65	170/110	2560	50.5	5170	− 5		

RESULTS. The results listed in Table 1 and Figures 1 and 2 reveal a decrease in total blood volume of from 1 to 16% in 9 of the 10 subjects during the convalescent postoperative period. In most cases this was due to a decrease in red cell volume as manifested by a fall in hematocrit. These observations were made about 10 days postoperatively in order that the results would not be confused by the

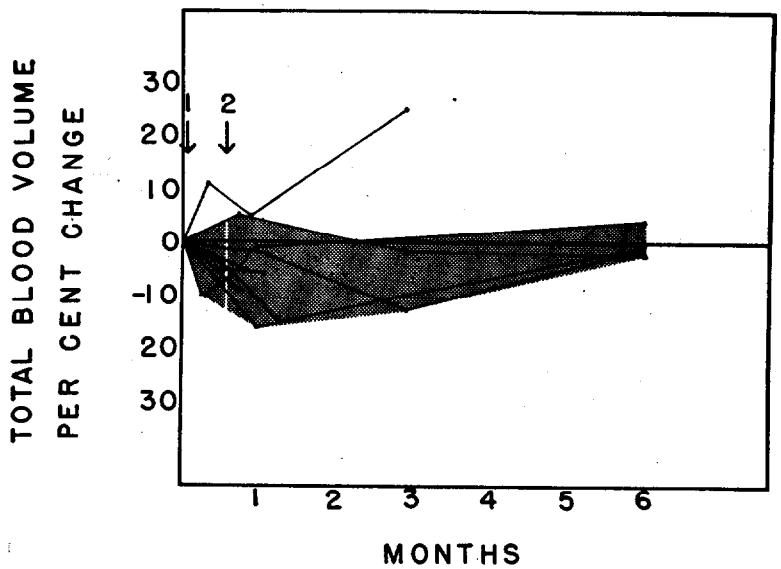

FIG. 1.—Per cent changes in total blood volume following lumbodorsal splanchnicectomy. The shaded area contains the values found in 9 of the 10 subjects studied. The arrows indicate the times of operation.

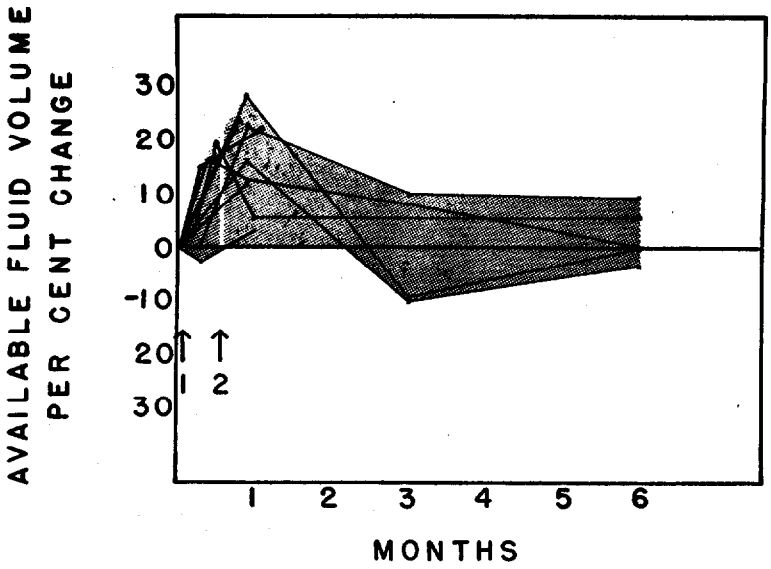

FIG. 2.—Per cent changes in "available fluid" volume following lumbodorsal splanchnicectomy. The shaded area contains the values fo ubjects studied. The arrows indicate the times of operation.

routine administration of blood and other parenteral fluids during the operative and immediate postoperative periods.

Coincident with the fall in total blood volume there was an increase in "available fluid" in all of the 9 cases studied varying from 3 to 28%. In all of the 5 patients followed for 6 months the total blood volume and "thiocyanate space" was restored to approximately the preoperative levels at the end of the period of observation. In 4 of these, however, the hematocrit remained slightly below the preoperative value, the deficiency being made up by a slight increase in plasma volume.

The decrease in total blood volume in the postoperative period has no relationship to changes in arterial pressure. Patients with slight or no fall in blood pressure exhibited the same decrease in total blood volume as those who had significant reductions in blood pressure. Thus, patient R. D. whose blood pressure preoperatively was 220/140 and 5 days postoperatively was 220/155 revealed a decrease in total blood volume of 10%. Patient J. S. whose blood pressure fell significantly from 208/105 preoperatively to 160/95 10 days postoperatively also exhibited a decrease in total blood volume of 5%.

Similarly, at the end of 6 months there was no correlation between changes in arterial pressure and changes in total blood volume. For example, the total blood volume had returned to within 2% of the preoperative value in both patient J. F. whose blood pressure was essentially unchanged and patient J. Mc. who exhibited a definite fall in arterial pressure from 165/135 to 135/95.

Discussion. The purpose of this investigation was to determine whether or not significant changes in blood volume and "available fluid" volume were produced following partial sympathectomy. Long-term observation of 5 patients revealed that at the end of 6 months following operation significant changes had not occurred, despite the fact that in the majority of these cases the blood pressure was significantly lower than the preoperative value.

However, during the course of the study definite trends in blood and available fluid volume were noted in the period from 8 days to 2 weeks after operation. These changes, which consisted of a reduction in red cell volume and an increase in "available fluid" volume, have been observed following other types of major surgery.[13] The fluctuations observed, therefore, cannot be considered to be a specific consequence of sympathectomy. Indeed, an increase in "thiocyanate space" has been observed in other conditions, such as lobar pneumonia[15] and infectious hepatitis,[12] as well as after surgical operations, and may represent simply a non-specific reaction of the body to injury.[17]

The failure of the hematocrit value to return to the preoperative level over a period of 6 months following operation is of interest. In dogs with experimentally induced polycythemia Schafer[16] has observed a definite reduction in red blood count following sympathectomy. He also noted a fall in hematocrit in a patient with polycythemia rubra vera who had undergone sympathectomy. Green[5] has reported a marked reduction in the hematocrit value following surgical excision of a pheochromocytoma in a patient who had chronic hypertension.

These observations suggest a relationship between the sympathetic nervous system and the red blood cell volume. However, the change may be more apparent than real, as it is possible that sympathectomy, by altering the caliber of the smaller vessels, may cause a redistribution of the red cell mass in the vascular system. This in turn would change the cell-plasma ratio in the larger vessels from which sampling is accomplished.[3,8,19]

On the basis of surface area the preoperative total blood volume values were within the normal range as defined by Gibson and Evans.[9] This is in agreement with the conclusion of Harris and Gibson[10] that the blood volume is normal in essential hypertension. The values for "avail-

able fluid" volume similarly fell within the normal range when compared on the basis of surface area.[18]

Summary and Conclusions. 1. Repeated blood and "available fluid" determinations were made on a series of 10 cases of essential hypertension for periods up to 6 months following lumbodorsal splanchnicectomy.

2. The total blood volume was reduced in 9 cases in the period from 8 days to 2 weeks following operation, due primarily to a diminution in red cell volume. Despite a continued reduction of blood pressure the total blood volume was restored to the approximate preoperative level at the end of 6 months following operation. A slight reduction of the hematocrit value persisted, the deficiency being made up by a compensatory increase in plasma volume.

3. Coincident with the reduction in blood volume noted in the 2nd postoperative week there was an increase in "available fluid" volume. This elevated value was restored to the preoperative level over a period of several months.

4. Previous observations that the total blood volume is within normal limits in patients with essential hypertension were confirmed.

5. In relation to surface area the "available fluid" volume of hypertensive subjects was also found to be within the normal range.

6. The reduction in blood pressure following sympathectomy is not dependent upon changes in total blood or "available fluid" volume.

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